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Practical Application of the Zürich-Montpellier System of Phytosociology

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Abstract: Practical application of the Zürich-Montpellier system of phytosociology is discussed. To illustrate its use and the methodology involved, reference is made to some vegetation samples from Westernport Bay, Victoria.

INTRODUCTION

The Zürich-Montpellier (Z-M) system attempts to describe stands of vegetation, and then group similar stands, using floristic similarity as a criterion. Hence it is a polythetic divisive system (Williams, Lambert and Lance 1966).

It has been applied to most vegetation types, and has the advantage that surveys covering large or small areas can be easily undertaken. Stand groups (usually arranged in a hierarchical structure) are particularly suitable for vegetation mapping.

There has been surprisingly little published in the English language on the theory and practice of the Z-M system. Notable exceptions have been Becking (1957) and Poore (1955a, b, c, 1956). Both of these authors dealt rather more with theoretical aspects of the system than with an explanation of the system's methodology.

More important, both freely utilize the concept of fidelity. Although this concept played an important part in the system's development, few proponents of the system now utilize it. Moore (1962), in commenting on Poore's (loc. cit.) observations, noted that the use of 'Charakterarten' (characteristic species) has now declined, and been largely replaced by 'Trennarten' (differential species). 'Differential species' implies that the species concerned serve to differentiate a unit of vegetation from similar units, but does not imply that the species is necessarily confined to that unit. The Trennarten of associations, taken as the basic units of the Z-M hierarchy, are termed 'Kennarten'.

As further comment on this problem, Ellenberg (1960) wrote '. . . the importance of characteristic species, or species of high fidelity, is decreasing more and more, and they only become important in the higher units of the system (alliance, order, class)'.

The system has been applied extensively in Europe, North and South America and Japan. That it can also be applied with great benefit in Australia the author has no doubt, and the prime reason for publishing this paper is to bring the methodology of the system within the reach of Australian ecologists who may wish to experiment with it.

METHODOLOGY

Two distinct phases are involved: 1. analysis (= description) and 2. synthesis (= classification).

1. Analysis

Here the most important feature involves 'stand selection', i.e. deciding the location and size of vegetation stands. ('Stand' is equivalent to the French 'Relevé', and German 'Aufnahme'.)

Stand selection depends on two major criteria:

a. Vegetational homogeneity;
b. Vegetation 'minimal area'.

Dahl and Hadeč (1949) give the following definition of **homogeneity**:

A *plant species* is said to be homogeneously distributed within a certain area, if the probability of catching an individual of the species, within a test area, is the same in all parts of the area. A plant community is said to be homogeneous if the individuals of the component species, used for community characterisation, are homogeneously distributed.

Poore (1955b) noted:

. . . it is quite clear that homogeneity is a matter of scale . . . In fact, the more one examines vegetation, the more one is forced to the conclusion that absolute uniformity is an illusion.

Bearing this in mind, it is nevertheless possible to distinguish between vegetation that approxi-

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mates to a standard of homogeneity, and one which is non-homogeneous (viz. the 'ecotone' between two well-defined vegetation types). Should such gradal situations be described, they will become obvious in the synthetic phase, and are best offset in any final tables of the vegetation.

Vegetation which obviously forms a mosaic is usually best treated as two vegetation types. Subsequent treatment in the synthesis phase may confirm this treatment, or show the mosaic effect to be produced by dominants only, and not borne out by total species composition.

Continental European phytosociologists have long relied on 'die pflanzensoziologische Blick', or assessment of homogeneity by eye. Many 'Anglo-American' ecologists have criticized this, perhaps unaware that it is not a haphazard process, but one in which the physiognomic structure of vegetation is assessed according to a very definite 'rule' of homogeneity.

If, at any stage, there are doubts regarding the homogeneity of any vegetation stand being described, then a note to this effect should be added.

'Minimal area' is based on the premise that the true characteristics of a plant community need a minimum area for expression, and any smaller areas examined would not indicate the full community characteristics. However, at the start of any investigation, no communities have been defined.

To overcome this circular argument, it is generally accepted that plant formations (sensu Dansereau 1957) are composed of communities with similar minimal areas. When working in a new formation, or unusual vegetation, an estimate of minimal area can be made using the following procedure:

a. Within an area 0·5 × 1 m count the number of species.
b. Double the area of the quadrat (i.e. 1 × 1 m), keeping the original area examined within the new area. Note any new species.
c. Continue this procedure, plotting the number of species noted against quadrat size.
d. The resultant graph should be a curve, with an initially sharp rise, but which levels out, or has a much diminished rate of increase.
e. The point of intersection between a perpendicular, dropped from the curve at the point of levelling out, and the horizontal axis is taken as the minimal area.

Assuming the vegetation to be homogeneous, and an area > the minimal area has been chosen, the following procedure should be adopted:

(1) Each description must have a unique code. This can vary with the purpose and needs of the recorder, i.e. it can be simple (1, A, etc.) or more detailed (PB/1/H), i.e. Author, number, vegetation type.

(2) For each description note:

a. Locality, as precisely as possible. (N.B.: in areas that are unmapped or have only old maps, a tracing sheet placed over an aerial photograph is a good method to show stand location, especially if there is a cluster of stands in an otherwise undistinguished region.)
b. Date—always in full, preferably as shown—12/X/'70 (i.e. day, month, year).
*e. Grid Reference
*d. Altitude
e. Slope
†f. Exposition
†g. Aspect
h. Tree layer height, % cover
i. Shrub layer height, % cover
j. Herb (field) layer height, % cover
k. Bryophyte (ground) layer height, % cover
l. Total Vegetation cover (%)
m. Where appropriate, note % cover of bare ground, rock or open water.
n. Area of the stand being analysed

** These details may be added later from maps or other sources.*

† 'Aspect' here refers to the most obvious feature of the vegetation (i.e. a species in full bloom); 'Exposition' to the compass point.

(3) In addition, a small sketch of the stand location is often useful.

(4) Soil profile; geological substratum. These are invaluable supplements to vegetation description. A sketch should be made of soil profile, noting any special features, particularly the development of the organic fraction. If possible, differentiate litter (L), fermentation (F) and humus (H) layers, leaching effects, water level, etc. In detailed studies, soil samples may be required for pH and mineral analysis. Distinguish solid and drift geological substrata, and note any outcrops.

(5) Note any unusual feature, i.e. roadside, regularly disturbed, subject to sea-spray, etc.

(6) Add any biotic data you consider important, i.e. intensive grazing (specify animal(s) if possible), excessive ant activity, etc.

(7) Make a complete list of all species present—include bryophytes, lichens and, if present, macroscopic algae. Epiphytes should be noted as such, but in certain vegetation types (e.g. Rain forests) it is possible that the epiphytic communities should be described separately (see Barkman 1959).

(8) Each species should then be assigned a value on a cover abundance scale, and, if possible, a sociability (mode of growth) scale. The use of these scales serves a two-fold purpose:

(i) they create a mental picture (for readers) of the vegetation described, and
(ii) they help to distinguish vegetation types, which, although floristically similar, may have different species acting as dominants. This is especially important in species-poor vegetation. Although there are several scales of cover-abundance in the literature, unless detailed work is being carried out the scale least subject to 'operator error' is that of Braun-Blanquet (1928) (see Appendix). Other scales, suitable for more detailed work, are those of Domin (1933), Doing-Kraft (1954), Barkman, Doing and Segal (1964). Note here also that 'cover' is defined as the 'amount of ground space that would be covered by an irregular polygon tracing the outline of the plant'. For a justification, see Daubenmire (1968).

(9) In the early days of the systems' development 'vitality' and phenology (i.e. seedling, flowering, fruiting, etc.) were also noted for each species, on a 1-5 scale. However, the use of these has been largely discontinued, with the exception that tree or shrub seedlings are usually noted separately, e.g. *Eucalyptus regnans* 5.1, *E. regnans* (seedlings) 1.1.

In extended surveys, it is often useful to have cards pre-printed with headings noted above, and a list of the more common species involved.

2. Synthetic Phase

As an example of this phase, 22 vegetation stands (each 5 sq. m in area) (taken from salt marsh vegetation, Westernport Bay, Victoria) are used for a step-by-step illustration of stages involved. The values quoted are from the cover-abundance and sociability scales of Braun-Blanquet (1928), with cover-abundance being quoted first. Although the tables are shown typed, normally they would be hand written.

(1) All stands are entered in a stands/species table (Table 1). This is the 'raw table'.

(2) This is then examined, and 'potential differential species' (PDS) noted. This has been done in Table (2), although normally one would use the raw table. The initial choice is made from species having an apparently clumped distribution, with usually $< 60\%$ presence in the stand group. Species such as *Distichlis distichophylla,* which may be a PDS, are ignored at this stage, but subsequently reordering may highlight this and other species, not obvious in this initial selection.

In the example there are 4 obvious groups of PDS:

a. the coincidence of *Atriplex cinereum* and *Selliera radicans.*
b. the coincidence of *Triglochin striata* and *Hemichroa pentandra.*
c. the coincidence of *Carpobrotus rossii, Poa poiformis, Triglochin striata* and *Frankenia pauciflora.*
d. The coincidence of *C. rossii, P. poiformis, Gahnia filum, Suaeda australis* and *F. pauciflora.*

At this stage, there is obvious overlap between (c) and (d)—subsequent testing will reveal if the distinction should be maintained.

(3) Using those species a new table (3) (the 'partial table') is drawn up, with a new order of stands, consolidating separated stands of the four groups discussed above. For easy and efficient transfer of information between the tables, the following procedure is recommended.

Two strips of squared paper are used, one with the numbers 1-22 entered sequentially. This is placed over the recorded stand numbers on the partial table. The second strip is placed over the raw table, and the position of the stand, as determined by its order in the partial table, is entered. Thus over stand 1 in the raw table 1 is entered, stand 2-2, stand 3-19, stand 4-20, etc. The two strips are illustrated under Table 3 (Fig. 1).

(4) From this partial table, it becomes obvious that there are, in fact, 3 species groups, each determined by a pair of species, and each capable of further differentiation. The three pairs are:

(i) *Atriplex cinereum—Selliera radicans*
(ii) *Triglochin striata—Hemichroa pentandra*
(iii) *Poa poiformis—Frankenia pauciflora*

It is also obvious that to clarify the subdivisions of (iii) a rearrangement of stands would help, i.e. as 13, 15, 3, 4, 14, 5, 6.

(5) Next a new partial table, with all species (excepting those of only one occurrence) is drawn up. This step may highlight any PDS previously ignored, and consolidate differentiated groups noted in 4. Again, transfer strips are used for ease in handling the data. This is Table (4) (partial table II).

(6) From the information gathered from partial table II, a third partial table (Table 5) is drawn up, revising the order of species. Stand 15 appears rather anomalous—this is set to one side for further consideration, but otherwise the stand order is unchanged. It can be useful, at this stage, to space out the defined groups.

It should be stressed that transfers of species values are made each time from the raw table,

and never from partial table to partial table.

(7) This last Table (5) represents the state of the vegetation as far as our knowledge extends at the time of investigation. Gathering of further stands, however, may increase the information, indicating a need for fusion, or perhaps subdivision, of the units described above.

NOMENCLATURE

Associations are usually named from a species acting as a physiognomic dominant, and another species constantly present, but not necessarily a physiognomic dominant. Similar associations, differentiated from others by the same set of differential species, may be grouped as alliances, and similar alliances grouped as orders, etc.

The 'endings' for the various hierarchical ranks are cited below (lowest rank at bottom):

Class	*-etea*
Order	*-etalia*
Alliance	*-ion*
Association	*-etum*
Sub-Association	*-etosum*
Variant	*no ending, or -osum*

To illustrate the three associations from this example three 'final tables' have been prepared (6-8).

These three associations most probably belong to the class Thero-Salicornietea.

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Appendix:

A. Cover/Abundance Scale

The one recommended is that of Braun-Blanquet (1928), i.e.:

r = erratic, cover less than 5%.
\+ = occasional cover, less than 5%.
1 = common, cover less than 5%.
2 = very common, cover less than 5% *or* cover 5-20%, any no. of individuals.
3 = cover 20-50%, any no. of individuals.
4 = cover 50-75%, any no. of individuals.
5 = cover 75-100%, any no. of individuals.

B. Sociability

Braun-Blanquet (1928):

1 = growing singly; solitary plants.
2 = growing in groups; clumps or tufted plants.
3 = large groups or clumps; small scattered patches.
4 = patches, or broken mat.
5 = extensive mat, covering nearly all stand area.

Note: The + symbol is not usually associated with values on the sociability scale.

Table 1

Raw Table

Stand #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Species:																						
Salicornia quinqueflora	3.3	4.4	2.1	3.3	5.5	2.2	1.1	2.1	5.5	3.3	4.4	3.3		4.4	3.3	3.1	2.1	3.1	1.1	2.1	2.1	3.1
Arthrocnemum arbusculum	4.4	4.4	3.1	3.1		+	2.1	2.1		4.4	3.1	5.5	3.1			4.4	5.5		+		1.1	+
Distichlis distichophylla	3.3	2.2	2.2							2.2	3.3	3.3	2.2			1.2	1.2	+	1.2	+	2.2	+
Samolus repens	1.2	2.3	+	1.1	+		5.5	3.3	2.2	2.3	2.3	1.3	+	1.1		3.3	3.2		5.5	1.1	3.3	2.2
Atriplex cinereum	+	+								+	+	1.2				1.2	+					
Selliera radicans	1.2	2.1								+	+	+				+	1.1			+	1.1	2.2
Carpobrotus rossii			3.3	4.4									3.3		3.3	4.4						
Poa poiformis			1.2	2.2	2.2	1.2							1.2	1.2	1.2							
Gahnia filum			3.2	2.2						2.2	2.2	2.2	3.2									
Suaeda australis			1.1	+								1.1				1.1	1.1					
Frankenia pauciflora			3.3	1.1		2.3							3.3	2.1	3.3							
Triglochin striata					1.2	+	2.1	2.1	1.1	+				2.2	+	+		1.1	2.1	+	2.1	2.1
Parapholis incurva						2.2									1.2							1.2
Hemichroa pentandra							2.1	3.2	2.1							1.2	+	4.4	2.1	5.5	3.3	3.3
Limonium australis							1.1												1.1		2.1	
Stipa teretifolia								1.2														
Rhizoclonium spp.																3.3	4.4					
Hydrocotyle capillaris																						1.2
Schoenus nitens																						1.2

Table 2

Raw Table—indicating 'potential differential species'

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Salicornia quinqueflora	3.3	4.4	2.1	3.3	5.5	2.2	1.1	2.1	5.5	3.3	4.4	3.3		4.4	3.3	3.1	2.1	3.1	1.1	2.1	2.1	3.1
Arthrocnemum arbusculum	4.4	4.4	3.1	3.1		+	2.1	2.1		4.4	3.1	5.5	3.1			4.4	5.5		+		1.1	+
Distichlis distichophylla	3.3	2.2	2.2							2.2	3.3	3.3	2.2			1.2	1.2	+	1.2	+	2.2	+
Samolus repens	1.2	2.3	+	1.1	+		5.5	3.3	2.2	2.3	2.3	1.3	+	1.1		3.3	3.2		5.5	1.1	3.3	2.2
Atriplex cinereum	+	+								+	+	1.2				1.2	+					
Selliera radicans	1.2	2.1								+	+	+				+	1.1			+	1.1	2.2
Carpobrotus rossii			3.3	4.4									3.3		3.3	4.4						
Poa poiformis			1.2	2.2	2.2	1.2							1.2	1.2	1.2							
Gahnia filum			3.2	2.2						2.2	2.2	2.2	3.2									
Suaeda australis			1.1	+								1.1				1.1	1.1					
Frankenia pauciflora			3.3	1.1		2.3							3.3	2.1	3.3							
Triglochin striata					1.2	+	2.1	2.1	1.1	+				2.2	+	+		1.1	2.1	+	2.1	2.1
Parapholis incurva						2.2									2.2							1.2
Hemichroa pentandra							2.1	3.2	2.1							1.2	+	4.4	2.1	5.5	3.3	3.3
Limonium australis							1.1												1.1		2.1	
Stipa teretifolia								1.2														
Rhizoclonium spp.																3.3	4.4					
Hydrocotyle capillaris																						1.2
Schoenus nigricans																						1.2

Table 3

Partial table I

	1	2	10	11	12	16	17	7	8	9	18	19	20	21	22	13	14	15	3	4	5	6
Atriplex cinereum	+	+	+	+	1.2	1.2	+															
Selliera radicans	1.2	2.1	+	+	+	+	1.1						+	1.1	2.2							
Triglochin striata			+			+		2.1	2.1	1.1	1.1	2.1	+	2.1	2.1		2.2	+			1.2	+
Hemichroa pentandra						1.2	+	2.1	3.2	2.1	4.4	2.1	5.5	3.3	3.3							
Carpobrotus rossii						4.4										3.3		3.3	3.3	4.4		
Poa poiformis																1.2	1.2	1.2	1.2	2.2	2.2	1.2
Frankenia pauciflora																3.3	2.1	3.3	3.3	1.1		2.3
Gahnia filum			2.2	2.2	2.2											3.2			3.2	2.2		
Suaeda australis					1.1	1.1	1.1												1.1	+		

Fig. [1]

Strip sequence:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
[PARTIAL TABLE]																						
revised stand order:	1	2	10	11	12	16	17	7	8	9	18	19	20	21	22	13	14	15	3	4	5	6
Strip sequence:	1	2	19	20	21	22	8	9	10	3	4	5	16	17	18	6	7	11	12	13	14	15
[RAW TABLE]																						
original stand order:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22

Table 4

Partial table II

	1	2	10	11	12	16	17	7	8	9	18	19	20	21	22	13	15	3	4	14	5	6
Atriplex cinereum	+	+	+	+	1.2	1.2	+															
Selliera radicans	1.2	2.1	+	+	+	+	1.1						+	1.1	2.2							
Triglochin striata			+			+		2.1	2.1	1.1	1.1	2.1	+	2.1	2.1		+			2.2	1.2	+
Hemichroa pentandra						1.2	+	2.1	3.2	2.1	4.4	2.1	5.5	3.3	3.3							
Poa poiformis																1.2	1.2	1.2	2.2	1.2	2.2	1.2
Frankenia pauciflora																3.3	3.3	3.3	1.1	2.1		2.3
Carpobrotus rossii						4.4										3.3	3.3	3.3	4.4			
Gahnia filum			2.2	2.2	2.2											3.2		3.2	2.2			
Suaeda australis					1.1	1.1	1.1											1.1	+			
Salicornia quinqueflora	3.3	4.4	3.3	4.4	3.3	3.1	2.1	1.1	2.1	5.5	3.1	1.1	2.1	2.1	3.1		3.3	2.1	3.3	4.4	5.5	2.2
Arthrocnemum arbusculum	4.4	4.4	4.4	3.1	5.5	4.4	5.5	2.1	2.1			+		1.1	+	3.1		3.1	3.1			+
Distichlis distichophylla	3.3	2.2	2.2	3.3	3.3	1.2	1.2				+	1.2	+	2.2	+	2.2		2.2				
Samolus repens	1.2	2.3	2.3	2.3	1.3	3.3	3.2	5.5	3.3	2.2		5.5	1.1	3.3	2.2	+		+	1.1	1.1	+	
Parapholis incurva															1.2		2.2					2.2
Limonium australis								1.1				1.1		2.1								
Rhizoclonium spp.						3.3	4.4															

Table 5

Partial table III

	1	2	10	11	12	16	17	7	8	9	18	19	20	21	22	13	3	4	14	5	6	15
Atriplex cinereum	+	+	+	+	1.2	1.2	+															
Salliera radicans	1.2	2.1	+	+	+	+	1.1						+	1.1	2.2							
Arthrocnemum arbusculum	4.4	4.4	4.4	3.1	5.5	4.4	5.5	2.1	2.1			+		1.1	+	3.1	3.1	3.1			+	
Distichlis distichophylla	3.3	2.2	2.2	3.3	3.3	1.2	1.2				+	1.2	+	2.2	+	2.2	2.2					
Triglochin striata			+			+		2.1	2.1	1.1	1.1	2.1	+	2.1	2.1				2.2	1.2	+	+
Hemichroa pentandra						1.2	+	2.1	3.2	2.1	4.4	2.1	5.5	3.3	3.3							
Poa poiformis																1.2	1.2	2.2	1.2	2.2	1.2	1.2
Frankenia pauciflora																3.3	3.3	1.1	2.1		2.3	3.3
Carpobrotus rossii						4.4										3.3	3.3	4.4				3.3
Gahnia filum			2.2	2.2	2.2											3.2	3.2	2.2				
Suaeda australis					1.1	1.1	1.1										1.1	+				
Rhizoclonium spp.						3.3	4.4															
Samolus repens	1.2	2.3	2.3	2.3	1.3	3.3	3.2	5.5	3.3	2.2		5.5	1.1	3.3	2.2	+	+	1.1	1.1	+		

Table 6

Arthrocnemo—Atriplicetum cinerei

	1	2	10	11	12	16	17
DIFFERENTIAL SPP. OF THE VARIANTS:							
Gahnia filum			2.2	2.2	2.2		
Hemichroa pentandra						1.2	+
Suaeda australis					1.1	1.1	1.1
Rhizoclonium spp.						3.3	4.4
DIFFERENTIAL SPP. OF THE ASSOCIATION:							
Arthrocnemum arbusculum	4.4	4.4	4.4	3.1	5.5	4.4	5.5
Distichlis distichophylla	3.3	2.2	2.2	3.3	3.3	1.2	1.2
Atriplex cinereum	+	+	+	+	1.2	1.2	+
Salliera radicans	1.2	2.1	+	+	+	+	1.1
SPECIES OF THE ALLIANCE:							
Salicornia quinqueflora	3.3	4.4	3.3	4.4	3.3	3.1	2.1
Samolus repens	1.2	2.3	2.3	2.3	1.3	3.3	3.2
ADDITIONAL SPECIES:							
Triglochin striata			+			+	

Table 7

Triglochio—Hemichroetum pentandrae

	7	8	9	18	19	20	21	22
DIFFERENTIAL SPP. OF THE VARIANTS:								
Arthrocnemum arbusculum	2.1	2.1			+		1.1	+
Selliera radicans						+	1.1	2.2
Distichlis distichophylla				+	1.2	+	2.2	+
DIFFERENTIAL SPP. OF THE ASSOCIATION:								
Triglochin striata	2.1	2.1	1.1	1.1	2.1	+	2.1	2.1
Hemichroa pentandra	2.1	3.2	2.1	4.4	2.1	5.5	3.3	3.3
SPECIES OF THE ALLIANCE:								
Salicornia quinqueflora	1.1	2.1	5.5	3.1	1.1	2.1	2.1	3.1
Samolus repens	5.5	3.3	2.2		5.5	1.1	3.3	2.2
ADDITIONAL SPECIES:								
Limonium australis	1.1				1.1		2.1	

Table 8

Frankenio—Poetum poiformis

	13	3	4	14	5	6
DIFFERENTIAL SPP. OF THE VARIANTS:						
Arthrocnemum arbusculum	3.1	3.1	3.1			
Carpobrotus rossii	3.3	3.3	4.4			
Gahnia filum	3.2	3.2	2.2			
Distichlis distichophylla	2.2	2.2				
Suaeda australis		1.1	+			
Triglochin striata				2.2	1.2	+
DIFFERENTIAL SPP. OF THE ASSOCIATION:						
Poa poiformis	1.2	1.2	2.2	1.2	2.2	1.2
Frankenia pauciflora	3.3	3.3	1.1	2.1		2.3
SPECIES OF THE ALLIANCE:						
Salicornia quinqueflora		2.1	3.3	4.4	5.5	2.2
Samolus repens	+	+	1.1	1.1	+	
ADDITIONAL SPECIES:						
Parapholis incurva						2.2